

WHAT IS CLAIMED IS:

1 1. A method of delivering a nebulized fluid for inhalation, comprising the
2 steps of:

3 providing a nebulizing device, a reservoir and a container, the reservoir and
4 container being replaceable;

5 delivering a volume of fluid from the container to the reservoir;

6 using the nebulizing element to nebulize the volume of fluid;

7 repeating the delivering and using steps a number of times with the same
8 container;

9 removing and replacing the container; and

10 removing and replacing the reservoir.

1 2. The method of claim 1, wherein:

2 the providing step is carried out with the nebulizing device having a vibrating
3 element with a plurality of holes, the reservoir holding a fluid in contact with the vibrating
4 element.

1 3. The method of claim 1, wherein:

2 the removing and replacing steps are carried out with the reservoir being mounted
3 to the container by the user which is followed by the user mounting both components together
4 into the nebulizing device.

1 4. The method of claim 1, wherein:

2 the providing step is carried out with reservoir having a needle which penetrates
3 the container thereby providing a fluid path between the container and the reservoir.

1 5. The method of claim 1, wherein:

2 the providing step is carried out with a one-way valve positioned along a fluid
3 path between the container and the reservoir.

1 6. The method of claim 5, wherein:

2 the providing step is carried out with the nebulizing device having a vibrating

3 assembly, the vibrating assembly having a plurality of holes therein; and
4 the delivering step is carried out with the valve directing the fluid at the vibrating
5 assembly; and
6 the using step is carried out with the fluid passing through the holes in the
7 vibrating assembly.

1 7. The method of claim 5, wherein:
2 the delivering step is carried out with the valve delivering a stream of the fluid.

1 8. The method of claim 7, wherein:
2 the delivering step is carried out with the stream of fluid being directed at a
3 vibrating assembly of the nebulizing device.

1 9. The method of claim 4, wherein:
2 the providing step is carried out with the valve positioned at the end of the fluid
3 path so that the valve leads directly into the reservoir.

1 10. The method of claim 1, further comprising the step of:
2 removing a mouthpiece before the removing steps to permit at least one of the
3 reservoir and the container to be removed and replaced.

1 11. The method of claim 10, wherein:
2 the removing steps are carried out with the reservoir and the container being
3 separate units.

1 12. The method of claim 11, wherein:
2 the removing steps are carried out with the reservoir being mounted to the
3 container by the user.

1 13. A nebulizer for nebulizing a fluid for inhalation by a user, comprising:
2 a housing;
3 a nebulizing element contained in the housing;

4 a container which holds a number of doses of the fluid to be nebulized, the
5 container being removable and replaceable;
6 a reservoir coupled to the housing, the reservoir holding a volume of the fluid in
7 contact with the nebulizing element, the reservoir being removable and replaceable; and
8 a fluid path between the container and the reservoir through which the volume of
9 fluid is delivered from the container to the reservoir.

1 14. The nebulizer of claim 13, wherein:
2 the nebulizing element includes a vibrating element with a plurality of holes; and
3 the reservoir holds the fluid in contact with the vibrating element.

1 15. The nebulizer of claim 13, wherein:
2 the container and fluid path are removed and replaced with the reservoir.

1 16. The nebulizer of claim 13, wherein:
2 the reservoir is mounted to the container by the user.

1 17. The nebulizer of claim 13, wherein:
2 the fluid path includes a needle which penetrates the container.

1 18. The nebulizer of claim 13, wherein:
2 the fluid path includes a one-way valve positioned between the container and the
3 reservoir.

1 19. The device of claim 18, wherein:
2 the nebulizing element has a vibrating assembly with a plurality of holes, the fluid
3 passing through the holes in the vibrating assembly; and
4 the valve directing the fluid at the vibrating assembly.

1 20. The device of claim 18, wherein:
2 the valve delivers a stream of the fluid.

1 21. The device of claim 20, wherein:

the nebulizing element has a vibrating assembly having a vibrating element with a plurality of holes; and
the valve delivers the stream at the vibrating assembly.

22. The nebulizer of claim 13, further comprising:
a removable mouthpiece, the mouthpiece being removed to permit at least one of the reservoir and container to be removed and replaced.

23. The nebulizer of claim 22, wherein:
the mouthpiece holds the nebulizing element.

24. The nebulizer of claim 13, wherein:
the nebulizing element is removable.

25. A removable and replaceable reservoir which holds and delivers a fluid to a nebulizer, comprising:

a reservoir having a chamber which has an opening therein, the opening being configured to mate with a nebulizing assembly, the opening having a diameter of 0.05 to 0.25 inch and

a connector for coupling to a generally cylindrical fluid container, the connector being configured to orient the cylindrical fluid container along an axis of symmetry, the axis of symmetry forming an angle of 0 to 45 degrees relative to the opening.

26. The reservoir of claim 25, further comprising:
a fluid path leading from the reservoir to the connector;
the connector also having a fluid coupling which provides fluid communication with the container when the container is mounted to the reservoir.

27. The reservoir of claim 26, wherein:
the fluid coupling is a needle which penetrates a septum of the container when the container is mounted to the reservoir.

28. The reservoir of claim 26, further comprising:

2 a one-way valve positioned along the fluid path, the one-way valve permitting
3 flow from the container to the reservoir and preventing flow in the reverse direction.

1 29. The device of claim 28, wherein:
2 the nebulizing element has a vibrating and the valve directing the fluid at the
3 vibrating assembly.

1 30. The device of claim 29, wherein:
2 the vibrating assembly has a plurality of holes, the fluid passing through the holes
3 in the vibrating assembly.

1 31. The device of claim 28, wherein:
2 the valve delivers a stream of the fluid.

1 32. The device of claim 31, wherein:
2 the nebulizing element has a vibrating assembly having a vibrating element with a
3 plurality of holes; and
4 the valve delivers the stream at the vibrating assembly.

1 33. The reservoir of claim 25, wherein:
2 the open end of the reservoir is oriented at an angle of about 15 degrees relative to
3 the axis of symmetry of the connector.

1 34. The reservoir of claim 25, wherein:
2 the open end of the reservoir has a diameter of about 0.15 inch.

1 35. The reservoir of claim 25, wherein:
2 the reservoir has a hydrophobic inner surface.

1 36. The reservoir of claim 25, wherein:
2 the reservoir has a smooth inner surface which is substantially free of corners and
3 seams.

1 37. The reservoir of claim 25, wherein:

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2 the reservoir has a tear-drop shape.

1 38. A removable and replaceable reservoir which holds and delivers a fluid to
2 a nebulizer, comprising:

3 a reservoir having an open end, the open end sealing with a nebulizing assembly
4 and having a diameter of about 0.15 inch, the open end generally lying in a plane;

5 a fluid path leading from the container to the reservoir; and

6 a connector for coupling to a generally cylindrical fluid container, the connector
7 being configured to orient the cylindrical fluid container along an axis of symmetry;

8 wherein axis of symmetry forms an angle with the plane of about 15 degrees.

1 39. A fluid vial, comprising:

2 a vial having a body and a chamber which holds a fluid;

3 a piston positioned in the body and slidable within the body to force fluid from the
4 chamber;

5 a connector having at least one protrusion extending radially outward which
6 engages a complementary slot in a fluid delivery device.

1 40. The fluid vial of claim 39, wherein:

2 the connector is a collar positioned around a cap on the body.

1 41. The fluid vial of claim 39, wherein:

2 the connector has three protrusions.

1 42. The fluid vial of claim 39, wherein:

2 the protrusions have a substantially square cross-sectional shape.

1 43. The fluid vial of claim 39, further comprising:

2 a locking connector which locks to a reservoir which holds a volume of the fluid.

1 44. The fluid vial of claim 45, wherein:

2 the locking connector has at least one tab extending longitudinally from the end of
3 the vial.

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1 53. The device of claim 50, wherein:
2 the nebulizing element has a vibrating assembly having a vibrating element with a
3 plurality of holes; and
4 the valve delivers the stream at the vibrating assembly.

1 54. The assembly of claim 50, wherein:
2 the one-way valve is a slit-valve.

1 55. The assembly of claim 50, wherein:
2 the one-way valve directs the fluid at the nebulizing element.

1 56. The assembly of claim 55, wherein:
2 the one-way valve directs the fluid at the nebulizing element as a stream of liquid.

1 57. The assembly of claim 50, wherein;
2 the valve is positioned at the end of the fluid path.

1 58. The assembly of claim 46, wherein the container and reservoir are separate
2 components which are coupled together by the user.

1 59. A removable and replaceable container and reservoir assembly for a
2 nebulizer, comprising:
3 a container having a piston, the container having a housing which houses a fluid,
4 the piston being movable within the housing to force fluid from the container, the piston moving
5 generally along a longitudinal axis of the housing;
6 a reservoir which holds liquid to be nebulized, the reservoir having an open end
7 which delivers fluid to the nebulizer when the reservoir is mounted to the device, the open end of
8 the reservoir has a diameter of 0.05 to 0.25 inch, the open end of the reservoir being oriented at
9 an angle of about 0 to 45 degrees relative to the longitudinal axis of the housing; and
10 a fluid path between the container and reservoir.

1 60. The assembly of claim 59, wherein:

2 the fluid path includes a one-way valve which permits fluid flow toward the
3 reservoir.

1 61. The assembly of claim 59, wherein:
2 the reservoir is mounted to the container by the user when the assembly is
3 replaced in the nebulizer.

1 62. A mouthpiece for a nebulizing device, comprising:
2 a connector configured to be coupled to a housing of the nebulizing device;
3 a nebulizing element positioned to emit a nebulized fluid into the chamber;
4 a chamber having at least one air inlet opening through which a user inhales
5 ambient air, the air inlet opening being positioned to produce an air flow in the chamber which
6 entrains the fluid nebulized by the nebulizing element.

1 63. The mouthpiece of claim 62, further comprising:
2 an electrical connector which electrically couples the mouthpiece to the
3 nebulizing device when the mouthpiece is mounted to the nebulizing device with the connector.

1 64. The mouthpiece of claim 62, wherein:
2 the mouthpiece has a pressure measurement port for measuring the pressure in the
3 chamber.

1 65. The mouthpiece of claim 64, wherein:
2 the pressure measurement port is configured to be coupled to a pressure
3 measurement conduit in the nebulizing assembly.

1 66. The mouthpiece of claim 62, wherein:
2 the nebulizing element is mounted to the housing with a resilient connection.

1 67. The mouthpiece of claim 62, wherein:
2 the nebulizing element includes a vibrating element with holes, the nebulized
3 fluid being emitted through the holes in the vibrating element when the vibrating element is
4 vibrated.

Abstract

1 68. The mouthpiece of claim 67, wherein:
2 the vibrating element has a front side leading to the chamber so that nebulized
3 fluid passing through the holes enters the chamber, the vibrating assembly also having a backside
4 which receives the fluid to be nebulized.

1 69. The mouthpiece of claim 67, further comprising:
2 a fluid connector configured to mate with a corresponding connector on a fluid
3 assembly which contains a fluid, the fluid connector directing fluid to the backside of the
4 vibrating element.

1 70. The mouthpiece of claim 62, wherein:
2 the nebulizing element is oriented at an angle of about 0-45 degrees relative to
3 horizontal during operation.

1 71. A mouthpiece for a nebulizing device, comprising:
2 a connector configured to be coupled to a housing of the nebulizing device;
3 a nebulizing element positioned to emit a nebulized fluid into the chamber;
4 a chamber having at least one air inlet opening through which a user inhales
5 ambient air, the air inlet opening being positioned to produce an air flow in the chamber which
6 entrains the fluid nebulized by the nebulizing element.
7 an electrical connector which electrically couples the mouthpiece to the
8 nebulizing device when the mouthpiece is mounted to the nebulizing device;
9 a pressure measurement port configured to be coupled to a pressure measurement
10 conduit in the nebulizing assembly.

1 72. The mouthpiece of claim 71, wherein:
2 the nebulizing element is mounted to the housing with a resilient connection.

1 73. The mouthpiece of claim 71, wherein:
2 the nebulizing element includes a vibrating element with holes, the nebulized
3 fluid being emitted through the holes in the vibrating element when the vibrating element is
4 vibrated.

74. The mouthpiece of claim 73, wherein:

the vibrating element has a front side leading to the chamber so that nebulized fluid passing through the holes enters the chamber, the vibrating assembly also having a backside which receives the fluid to be nebulized.

75. The mouthpiece of claim 73, further comprising:

a fluid connector configured to mate with a corresponding connector on a fluid assembly which contains a fluid, the fluid connector directing fluid to the backside of the vibrating element.

76. A nebulizing device for nebulizing a fluid, comprising:

a housing;

a vibrating assembly contained within the housing, the vibrating assembly including a nebulizing element and a piezoelectric element, the nebulizing element having a plurality of holes through which the nebulized fluid exits, the piezoelectric element being coupled to the nebulizing element to vibrate the nebulizing element; and

a resilient mounting which couples the vibrating assembly to the housing.

77. The nebulizing device of claim 76, further comprising:

a fluid connector coupled to the resilient mounting, the resilient mounting providing a closing force between the fluid connector and a removable and replaceable fluid assembly which holds the fluid.

78. The nebulizing device of claim 76, wherein:

the resilient mounting includes an elastic material.

79. The nebulizing device of claim 78, wherein:

the elastic material is an elastomeric material.

80. A nebulizing device for delivering nebulized fluids for inhalation,

comprising:

a housing having a mouthpiece for inhalation of a nebulized fluid by the user;

4 a vibrating element mounted within the housing, the vibrating element having a
5 plurality of holes therein through which the nebulized fluid emerges;
6 a container which contains a fluid;
7 a reservoir which holds a volume of the fluid delivered from the container; and
8 a fluid path between the container and the reservoir to deliver fluid from the
9 container to the reservoir.

1 81. The nebulizing device of claim 80, wherein:
2 the container is removable and replaceable.

1 82. The nebulizing device of claim 80, wherein:
2 the reservoir is removable and replaceable.

1 83. The nebulizing device of claim 80, wherein:
2 the reservoir and container are replaced at the same time.

1 84. The nebulizing device of claim 80, wherein:
2 the reservoir and container are coupled together.

1 85. The nebulizing device of claim 85, wherein:
2 the reservoir is mounted to the container by the user.

1 86. The nebulizing device of claim 80, wherein:
2 the vibrating element is generally oriented 0-45 degrees from vertical.

1 87. The nebulizing device of claim 80, wherein:
2 the reservoir has an inner surface which is hydrophobic.

1 88. The nebulizing device of claim 80, wherein:
2 the inner surface of the reservoir is substantially smooth and free of seams and
3 corners.

1 89. The nebulizing device of claim 88, wherein:
2 the inner surface of the reservoir is tear-drop shaped.

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- 1 90. The nebulizing device of claim 80, wherein:
2 the vibrating element is vibrated by a piezoelectric element.
- 1 91. The nebulizing device of claim 80, wherein:
2 the reservoir has a collection area located adjacent to the vibrating element where
3 a final drop of the fluid in the reservoir to be delivered accumulates, wherein the final drop
4 accumulated in the collection area is drawn over the holes when the vibrating element is vibrated.
- 1 92. The nebulizing device of claim 80, wherein:
2 the reservoir has at least one vent hole therein, the vent hole being sized to prevent
3 the fluid from escaping therethrough due to surface tension adhesion.
- 1 93. The nebulizing device of claim 86, wherein:
2 the vent hole is formed by a hole in the reservoir.
- 1 94. The nebulizing device of claim 80, wherein:
2 the fluid path includes a needle which pierces the container.
- 1 95. The nebulizing device of claim 80, wherein:
2 the fluid path includes a one-way valve which permits flow in the direction of the
3 reservoir and prevents flow back toward the container.
- 1 96. The device of claim 95, wherein:
2 the nebulizing element has a vibrating assembly with a plurality of holes, the fluid
3 passing through the holes in the vibrating assembly; and
4 the valve directing the fluid at the vibrating assembly.
- 1 97. The device of claim 95, wherein:
2 the valve delivers a stream of the fluid.
- 1 98. The device of claim 95, wherein:
2 the nebulizing element has a vibrating assembly having a vibrating element with a
3 plurality of holes; and

the valve delivers the stream at the vibrating assembly.

99. A method of nebulizing a fluid, comprising the steps of:

providing a nebulizer having a nebulizing element and a reservoir, the nebulizing element having a vibrating element with a plurality of holes therein, the nebulizer also having a container and a fluid path, the fluid path leading from the container to the reservoir and having a one-way valve which permits fluid flow into the reservoir; and

delivering a volume of fluid to the reservoir from the container so that the fluid accumulates in the reservoir and in contact with the plurality of holes; and

activating the nebulizer to nebulize the fluid in the reservoir, the vibrating element being vibrated so that the fluid in the reservoir is dispensed through the holes in the vibrating element.

100. The method of claim 99, wherein:

the providing step is carried out with the nebulizing element positioned at a hydrostatic location relative to the reservoir such that less than 25% of the volume of the reservoir lies below the nebulizing element.

101. The method of claim 99, wherein:

the providing step is carried out with the nebulizing element positioned at a hydrostatic location relative to the reservoir such that less than 10% of the volume of the reservoir lies below the nebulizing element.

102. The method of claim 99, wherein:

the valve is positioned at a hydrostatic location relative to the reservoir such that less than 25% of the volume of the reservoir lies below the valve.

103. The method of claim 99, wherein:

the delivering step is completed before the activating step is started.

104. The method of claim 99, wherein:

the providing step is carried out with the valve being positioned at a wall of the reservoir so that the valve isolates the entire fluid path.

105. The method of claim 104, wherein:

the providing step is carried out with the valve being a slit valve.

106. The method of claim 99, wherein:

the delivering step is carried out before the activating step so that the volume accumulates in the reservoir prior to the activating step.

107. The method of claim 99, wherein:

the providing step is carried out with the vibrating element being generally oriented 0-45 degrees relative to vertical.

108. The method of claim 99, wherein:

the providing step is carried out with the nebulizing element being vibrated by a piezoelectric element.

109. The method of claim 99, wherein:

the providing step is carried out with the reservoir having a collection area located adjacent to the nebulizing element;

the activating step is carried out with a final drop of fluid in the reservoir accumulating in the collection area, wherein the final drop is drawn over the holes in the nebulizing element.

110. The method of claim 99, wherein:

the providing step is carried out with an inner surface of the reservoir being hydrophobic.

111. The method of claim 99, wherein:

the providing step is carried out with the inner surface of the reservoir being substantially smooth and free of seams and corners.

112. The method of claim 99, wherein:

the providing step is carried out with the reservoir having a tear-drop shape.

1 113. The method of claim 99, wherein:
2 the providing step is carried out with the container holding a number of volumes
3 of the liquid and being replaceable.

1 114. The method of claim 99, wherein:
2 the providing step is carried out with the container and the reservoir both being
3 replaceable.

1 115. The method of claim 114, wherein:
2 the container is mounted to the reservoir and the container and reservoir are
3 removed and replaced at the same time.

1 116. The method of claim 99, wherein:
2 the fluid path includes a needle which pierces the container.

1 117. The method of claim 99, wherein:
2 the providing step is carried out with the nebulizing device having a vibrating
3 assembly, the vibrating assembly having a plurality of holes therein; and
4 the delivering step is carried out with the valve directing the fluid at the vibrating
5 assembly; and
6 the using step is carried out with the fluid passing through the holes in the
7 vibrating assembly.

1 118. The method of claim 99, wherein:
2 the delivering step is carried out with the valve delivering a stream of the fluid.

1 119. The method of claim 99, wherein:
2 the delivering step is carried out with the stream of fluid being directed at a
3 vibrating assembly of the nebulizing device.